Performance of the 1 h oral glucose tolerance test in predicting type 2 diabetes and association with impaired β-cell function in Asians: a national prospective cohort study

Michelle H. Lee,[a,b] Eveline Febriana,[a] Maybritte Lim,[a,c] Sonia Baig,[a] Liang Shen,[a] Mayank Dalakoti,[d,e] Nicholas Chew,[a,e] Tze Ping Loh,[f] Mark Chan,[a,e] Kee Seng Chia,[g] Alice Pik-Shan Kong,[h] Alex R. Cook,[g] Jeffrey B. Halter,[a,i] Faidon Magkos,[j] and Sue-Anne Toh[a,b,c,*]

[a]Yong Loo Lin School of Medicine, National University of Singapore, Singapore
[b]NOVI Health, Singapore
[c]Department of Medicine, National University Hospital, Singapore
[d]Department of Medicine, Ng Teng Fong General Hospital, Singapore
[e]Department of Cardiology, National University Heart Centre, Singapore
[f]Department of Laboratory Medicine, National University Hospital, Singapore
[g]Saw Swee Hock School of Public Health, National University of Singapore and National University Health System, Singapore
[h]Department of Medicine & Therapeutics, Faculty of Medicine, The Chinese University of Hong Kong SAR, China
[i]Division of Geriatric and Palliative Medicine, University of Michigan, USA
[j]Department of Nutrition, Exercise and Sports, University of Copenhagen, Denmark

The Lancet Regional Health - Western Pacific 2025;54: 101278
Published Online xxx
https://doi.org/10.1016/j.lanwpc.2024.101278

Summary

Background Postprandial glucose concentration 1-h (1 h-PG) after an oral glucose tolerance test (OGTT) has similar or superior performance to 2 h-PG in predicting type-2 diabetes mellitus (T2DM) in several populations, and is simpler to obtain in clinical practice. However, studies in Asians are scarce. We investigated the utility of elevated baseline 1 h-PG in predicting T2DM incidence within three years, and its relationship with β-cell function in 1250 non-diabetic Asian participants.

Methods Participants underwent an OGTT, an intravenous glucose challenge and a hyperinsulinemic-euglycemic clamp to determine glucose tolerance, acute insulin response (AIR) and insulin sensitivity at baseline. OGTTs were repeated every six months until study completion to monitor T2DM conversion.

Findings The area under the receiver operating characteristic curve of 1 h-PG was not significantly different from 2 h-PG ($AUC_{1h\text{-}PG}$ = 0.883 vs. $AUC_{2h\text{-}PG}$ = 0.907; ΔAUC = −0.024, P = 0.124) and the optimal 1 h-PG cut-off was ≥10.7 mmol/L. When groups of high/low 1 h-PG and 2 h-PG at baseline were compared, AIR and disposition index were significantly lower in groups with high 1 h-PG, and both had a stronger correlation with 1 h-PG, indicating that impaired β-cell function was more strongly associated with elevated 1 h-PG than 2 h-PG.

Interpretation The ability of 1 h-PG to detect Asians at risk of developing T2DM within three years is on par with 2 h-PG and the optimal cut-off is 10.7 mmol/L. Elevated 1 h-PG is associated with β-cell dysfunction. We conclude that 1 h-PG can be considered as a primary OGTT time point to identify Asians at risk for T2DM, allowing for screening at a reduced time and cost, and with lower patient burden.

Funding National Medical Research Council (NMRC), Ministry of Health (MOH; Singapore) Industry Alignment Fund [NMRC/MOHIAFCat1/0048/2016] and Janssen Pharmaceuticals Inc. (USA).

Keywords: 1 h-OGTT; Asian; Type 2 diabetes mellitus risk; Beta cell function; Screening

Introduction

The use of fasting plasma glucose concentration and glycated hemoglobin (HbA1c) have limited sensitivity to detect individuals at high risk of type-2 diabetes mellitus (T2DM).[1] Rather, glucose concentrations after a dynamic challenge, such as the oral glucose tolerance test

*Corresponding author. Department of Medicine, Yong Loo Lin School of Medicine, 1E Kent Ridge Road, Level 10, NUHS Tower Block, 119228, Singapore.
E-mail address: mdcsates@nus.edu.sg (S.-A. Toh).

Research in context

Evidence before this study

The 1-h OGTT postprandial glucose (1 h-PG) has performed equally well or even better than the 2 h-PG in identifying prediabetes and predicting risk of Type 2 Diabetes Mellitus (T2DM). The optimal cut-off of 8.6 mmol/L for predicting risk of T2DM was derived from studies in predominantly Caucasian populations, namely the San Antonio Heart Study, and the Botnia and Malmö Prevention Study cohorts. To evaluate the current evidence in Asian populations, we performed a PubMED search with the terms (1 h ogtt) AND (asian) from 2007 to 2023 and sieved our publications that assessed for an optimal 1 h-PG cut-off for predicting risk of T2DM. In addition, we studied the references of the Asian studies that were featured in the recently published 2024 International Diabetes Federation position statement on the use of 1 h-PG. Two Indian studies by the same group reported 8.5–8.6 mmol/L, while the Korean study was 8.0 mmol/L. However, the Japanese study found the optimal 1 h-PG cut-off to be 179 mg/dL (9.9 mmol/L) while the Chinese study reported the optimal 1 h-PG cut-off to be 9.25 mmol/L. The remaining two studies (Indian and Thai) did not perform sensitivity analysis to determine the optimal cut-off and used the recommended value of 8.6 mmol/L. Thus, a suitable 1 h-PG threshold for Asians remains unclear.

Added value of this study

We leveraged on a first-of-its-kind, deep metabolic phenotyping longitudinal study in Singapore representing major Asian ethnic groups in the region (Chinese, Malay, Indian). This study tracked progression to T2DM over a period of three years by undergoing an OGTT every 6 months, as well as changes in insulin sensitivity and secretion using the hyperinsulinemic-euglycemic clamp and intravenous glucose tolerance test to measure the acute insulin response respectively. With this cohort, we investigated the utility of elevated 1 h-PG at baseline in predicting the development of T2DM, and characterized the relationship of elevated 1 h-PG with the mechanisms regulating glucose homeostasis. We found that the diagnostic performance of 1 h-PG to detect Asians at risk of developing T2DM within three years is on par with 2 h-PG. The optimal threshold for identifying those at high risk is 10.7 mmol/L, which is significantly higher than the widely used cut-off of 8.6 mmol/L. Elevated 1 h-PG was associated with impaired insulin secretion and β-cell dysfunction.

Implications of all the available evidence

The optimal threshold for risk detection in our population was 10.7 mmol/L, which is significantly higher than the recommended value of 8.6 mmol/L in non-Asian populations. This is likely related to the Asian metabolic phenotype being substantially different from the Caucasian one, and underscores the importance of not assuming a one-size-fits-all approach as different ethnic populations are unique in their etiology of T2DM progression. If 8.6 mmol/L had been used in our population, the percentage of false positives would be 50%, which is much higher than 19% when 10.7 mmol/L was used. From a population health perspective, using a sub-optimal cut-off would place an unnecessary economic burden on population screening for T2DM risk. However, we also acknowledge that variability in thresholds can be attributed to the different follow up durations. Given the relatively higher contribution of impaired insulin secretion in the pathogenesis of T2DM in East Asians which represents the majority in our study population, as well as the time- and cost-saving advantage over the 2 h-PG, we recommend the 1 h-PG of cut-off 10.7 mmol/L be considered as a primary post-load glucose time point to identify Asians in this region who are at elevated risk for T2DM.

(OGTT), are more sensitive in predicting T2DM risk, despite being less reproducible.[2] Since the demonstration, in 1913, that ingested carbohydrates lead to fluctuations in circulating glucose,[3] multiple time-point OGTTs have been used in clinical medicine to assess glucose tolerance.[4] Much later, in the 1980s, the test was simplified to include just a single measurement of glucose concentration at 2 h after glucose ingestion, due to its strong association with the occurrence of diabetic retinopathy.[2] However, the current thresholds of 2-h glucose levels are apparently not optimal in capturing individuals at-risk. In the US, approximately 30% of those who developed T2DM within a ten year period had normal glucose tolerance at baseline.[5] Importantly, states of intermediate hyperglycemia such as prediabetes or impaired glucose tolerance (IGT) may already be associated with significant microvascular[6] and macrovascular[7,8] damage. Accordingly, there is a need to improve the diagnostic ability of the OGTT to identify those at-risk of T2DM.

In recent years, the 1-h OGTT postprandial glucose (1 h-PG) has performed equally well or even better than the 2 h-PG in identifying prediabetes and predicting risk of T2DM.[9–12] The 1 h-PG is also able to detect early stages of hyperglycemia even before the onset of IGT.[13] The widespread use of the "optimal" cut-off of 8.6 mmol/L[9,10] was derived from studies in predominantly Caucasian populations, namely the San Antonio Heart Study, and the Botnia and Malmö Prevention Study cohorts. In the 2024 International Diabetes Federation position statement on the use of 1 h-PG,[14] of the seven Asian cohort studies for T2DM prediction of 1 h-PG that were featured, the optimal 1 h-PG cut-offs reported for two Indian studies by the same group were 8.5–8.6 mmol/L,[15,16] while the Korean study was 8.0 mmol/L.[17] However, the Japanese study found the

optimal 1 h-PG cut-off to be 9.9 mmol/L[18] while the Chinese study reported the optimal 1 h-PG cut-off to be 9.25 mmol/L,[19] much higher than the recommended cut-off of 8.6 mmol/L. The remaining two studies (Indian[20] and Thai[21]) did not perform sensitivity analysis to determine the optimal cut-off and used the recommended value of 8.6 mmol/L. Thus, a suitable 1 h-PG threshold for Asians remains unclear.

An elevated 1 h-PG in non-Asian individuals who meet current criteria for normal glucose tolerance is associated with insulin resistance,[12] impaired β-cell function,[22] unfavorable inflammatory profile,[23] as well as an increased risk of developing diabetes-related complications such as cardiovascular disease and retinopathy.[24,25] Thus, assessing the relationship of 1 h-PG with the mechanisms regulating plasma glucose homeostasis (i.e., insulin sensitivity and insulin secretion) and evaluating its utility in predicting T2DM risk is beneficial for diagnostic purposes and can also have important practical implications by allowing for a shorter and more cost-effective OGTT in clinical medicine. In this present report, we leverage on a deep metabolic phenotyping longitudinal study in Singapore, which tracks progression to T2DM over a period of three years. We aimed to investigate the utility of elevated 1 h-PG at baseline in predicting the development of T2DM, and characterize the relationship of elevated 1 h-PG with the mechanisms regulating glucose homeostasis.

Methods

Study participants

The "Assessing the Progression to Type-2 Diabetes" (APT-2D) study is a nationwide, open cohort observational study in Singapore that tracked the natural progression of glycemic control among non-diabetic Asians over a period of 3 years or until conversion to T2DM.[26] Apparently healthy adults of both sexes, between the ages of 30 and 70 years, and of any body mass index (BMI), who were not on any long-term medications that could affect glucose metabolism, and had no prior history of diabetes, were recruited. Participants provided written informed consent prior to joining the study, which was approved by the Domain Specific Review Board of the National Healthcare Group (ref: 2016/00096) in Singapore and is registered with ClinicalTrials.gov (NCT02838693).

Experimental procedures

Participants came to the study site for up to nine visits, including two baseline visits (Visits 1 and 2), followed by monitoring visits every six months (Visits 3–8) and the final visit (Visit 9) over a period of 3 years (Supplementary Fig. S1). If a participant was found to have converted to T2DM during a monitoring visit, the participant immediately proceeded to Visit 9. For all visits, participants were admitted after having fasted overnight for 10–12 h. They were instructed to abstain from performing any strenuous exercise on the previous day, and from consuming fat-rich foods on the preceding three days, to avoid potential delayed metabolic effects of exercise and high-fat diet on metabolism. Participants arrived in the morning (~08:00 h). Height, weight and vital signs (heart rate and blood pressure) were obtained by standard methods after 5 min of rest, before any testing began. Additionally, for visits 2 and 9, body fat percent and fat-free mass (FFM) were assessed by using bioelectrical impedance analysis (Tanita Corporation, Japan).[27]

Oral glucose tolerance test (OGTT)

Participants underwent a 2-h OGTT during the first baseline visit and all monitoring visits (# 1 and 3–8). An indwelling catheter was inserted into an antecubital vein of one arm for blood sampling. A fasting blood sample was obtained at t = 0 min, and then participants ingested a solution containing 75 g of glucose; additional blood samples were obtained at t = 10, 20, 30, 60, 90 and 120 min for measurement of glucose, insulin and C-peptide concentrations. HbA1c was only measured fasting. Participants who were found to have undiagnosed T2DM after baseline Visit 1 were excluded from the study. T2DM was defined by using the American Diabetes Association criteria for fasting plasma glucose, 2 h-PG, and HbA1c.[28] At least two of the three parameters needed to be in the diabetic range: HbA1c ≥ 6.5%, fasting plasma glucose ≥7 mmol/L, or 2 h-PG ≥ 11.1 mmol/L. If only one of the three parameters was in the diabetic range, the participant would return within one month for a confirmatory test before the second visit. If the same parameter was still elevated, or if two of the three parameters were within the diabetic range during the confirmatory test, the participant would be classified as having newly diagnosed T2DM and would be excluded from the study. Prediabetes was defined by using the American Diabetes Association criteria of at least one of the three parameters: HbA1c is ≥ 5.7% and <6.5%, fasting plasma glucose is ≥ 5.6 mmol/L and <7.0 mmol/L, or 2 h-PG ≥ 7.8 mmol/L and <11.1 mmol/L.[28]

Intravenous glucose challenge and hyperinsulinemic-euglycemic clamp

During the second baseline and final study visits (# 2 and 9), indwelling catheters were inserted into an antecubital vein of one arm to infuse insulin and dextrose, and a forearm vein in the contralateral arm for blood sampling. A bolus of 50% dextrose (0.3 g of glucose per kg body weight) was administered intravenously and blood samples were obtained at t = 0 min (fasting) and at 2, 3, 4, 5, 6, 8 and 10 min from the opposite arm, for measurement of glucose and insulin concentrations, to determine the acute insulin response to glucose (AIR). Twenty minutes later, a 3-h

hyperinsulinemic-euglycemic clamp procedure was initiated. Insulin (Actrapid; NovoNordisk, Denmark) was infused at a constant rate of 60 mU per m^2 of body surface area per minute for the duration of the clamp procedure. Plasma glucose concentration was measured every 5 min at bedside and 20% dextrose solution was infused at a variable rate to maintain euglycemia (100 mg/dL or 5.6 mmol/L). Four additional blood samples were obtained (every 10 min) to determine glucose and insulin concentrations during the steady-state period of the clamp (last 30 min of the procedure).

Sample analysis

The concentration of plasma glucose during the intravenous glucose challenge and the euglycemic clamp procedure was measured by the glucose oxidase method on an automated glucose analyzer (YSI 2300; Yellow Spring Instruments, Yellow Springs, OH, USA). Plasma insulin and C-peptide concentrations were determined by chemiluminescence immunoassays (ADVIA Centaur XP; Siemens, Germany). HbA1c was measured in whole blood by cation-exchange high performance liquid chromatography (Bio-Rad Variant II Turbo; Bio-Rad, CA, USA). Plasma glucose during the OGTT was determined by the AU5822 general chemistry analyzer (Beckman Coulter, CA, USA) at the National University Hospital Referral Laboratory (accredited by the College of American Pathologists).

Calculations

Whole-body glucose uptake and insulin sensitivity

The average rate of dextrose infusion during the steady-state period of the clamp procedure (final 30 min) approximates the insulin-mediated whole-body glucose disposal (M-value, normalized to fat-free mass), as the relatively high insulin infusion rate (60 mU per m^2 of body surface area per min) is expected to almost completely suppress hepatic glucose production in people without diabetes.[29] Insulin sensitivity was calculated as the M/I ratio, i.e., glucose disposal divided by the steady-state plasma insulin concentration (i.e., average insulin concentration during the final 30 min of the clamp). The M/I ratio adjusts glucose disposal rate for potential differences in steady-state insulin concentrations attained during the clamp.[30]

Acute insulin response to intravenous glucose

AIR is a measure of first phase insulin secretion and was calculated as the incremental area under the insulin concentration curve, by using the trapezoid rule, during the first 10 min after the intravenous glucose bolus.[31]

Disposition index (DI)

The DI, a measure of the overall pancreatic β-cell function, was calculated as the product of insulin sensitivity and insulin secretion, i.e., M/I x AIR.

Statistical analysis

Statistical analyses were carried out with SPSS version 29 (IBM SPSS, Chicago, IL) and R version 4.4.2. Associations between continuous parameters were assessed by Pearson's correlation and comparisons between two groups were conducted by Student's T-test for independent samples. Steiger's Z-test was conducted to test the difference between two correlation coefficients obtained from the same sample, with the two correlations sharing one variable in common.[32] Receiver Operator Characteristics (ROC) curve analysis was used to assess the ability of the glucose parameters at baseline in discriminating future T2DM converters from controls. When demographic factors were included together with a glucose parameter in the analysis, logistic regression with T2DM incidence as the outcome was run to model the predicted probabilities before running the ROC analysis. Net Reclassification Improvement (NRI) and Integrated Discrimination Improvement (IDI) analyses were performed using *Hmisc* package in R.[9] To identify the optimal 1 h-PG threshold that maximizes the sum of sensitivity and specificity for incident T2DM prediction, the following parameters were calculated from the confusion matrix for each 1 h-PG cutoff value ranging from 7.6 to 11.5 mmol/L: sensitivity = $TP/(TP+FN)$; specificity = $TN/(TN+FP)$; Youden's index = sensitivity + specificity −1; positive predictive value = $TP/(TP+FP)$; negative predictive value = $TN/(TN+FN)$. To investigate the metabolic phenotype of individuals with elevated 1 h-PG and/or 2 h-PG, a subset of participants with FPG <5.6 mmol/L and HbA1c < 5.7% were categorized into four groups based on the presence (high) or absence (low) of 1 h-PG ≥ 10.7 mmol/L and 2 h-PG ≥ 7.8 mmol/L at baseline. Comparison between the four groups (1 h-PG_{low} 2 h-PG_{low} vs. 1 h-PG_{high} 2 h-PG_{low} vs. 1 h-PG_{low} 2 h-PG_{high} vs. 1 h-PG_{high} 2 h-PG_{high}) was conducted by using chi-square test for categorical variables and one-way ANOVA with Sidak's post-hoc tests for continuous variables. Adjustment for important subject characteristics that were significantly different between groups such as age, sex and BMI was performed by using analysis of covariance, followed by Sidak's post-hoc analysis.

Role of funding source

This work was supported by the National Medical Research Council (NMRC), Ministry of Health (MOH; Singapore) Industry Alignment Fund [NMRC/MOHIAF-Cat1/0048/2016] and Janssen Pharmaceuticals Inc. (USA). In-kind contributions were supported by the National University Hospital (NUH) and the National University of Singapore (NUS). The funders had no role in the writing of the manuscript or the decision to submit it for publication. The funders had no role in the data collection, analysis or interpretation, trial design or participant recruitment. The authors were not paid to write this article by a pharmaceutical company or any other agency. All

authors had full access to the full data in the study and accept responsibility to submit for publication.

Results

Study population characteristics

From April 2016 to December 2018, a total of 2668 participants provided informed consent for the study. Of these, 2126 proceeded to complete the initial baseline visit, while 416 either withdrew or were excluded from the study due to not meeting the inclusion criteria (e.g., absence of T2DM). The remaining 1710 participants completed the second baseline visit, of whom 1271 (74.3%) successfully completed the final study visit. However, 21 participants were subsequently excluded from the study (4 due to inability to confirm diabetes status, 9 due to failure to obtain accurate data during the metabolic tests, and 8 due to being of non-Asian descent). Therefore, data from 1250 participants of Asian descent were used in the analysis (Fig. 1). Out of the 1250 participants, 40.6% had prediabetes at baseline and 6.2% developed T2DM within 3 years (Table 1). The mean age and BMI were 48 ± 10 years and 25.0 ± 4.4 kg/m^2, respectively. There were slightly more females (57%) than males, and the majority were of Chinese ethnicity (70%), typical of the population distribution in Singapore (Table 1).

1 h-PG is equivalent to 2 h-PG in predicting T2DM incidence

The glucose indices (FPG, HbA1c, 1 h-PG and 2 h-PG) correlated with each other to a variable extent, with 1 h-PG having a strong correlation with 2 h-PG (Pearson's R = 0.729, $P < 0.001$); correlations of postprandial glucose concentrations with FPG and HbA1c were more modest, but all statistically significant (Pearson's R = 0.356–0.507, $P < 0.001$). The population distributions of the future T2DM converters had significantly higher mean values for all glucose parameters than the distributions of non-converters, with visually more distinct separation between populations for 1 h-PG and 2 h-PG (Fig. 2A and B) as compared to FPG and HbA1c (Fig. 2C and D).

The ROC curve analyses indicated that all glucose parameters had significant discriminatory ability for T2DM incidence (Table 2). While the 2 h-PG had a larger AUC_{ROC} (0.907 (0.878, 0.935)) than the 1 h-PG (0.883 (0.849, 0.917)), the two AUCs were not significantly different from each other (ΔAUC = –0.024 (–0.054, 0.007), $P = 0.124$, Table 2; Fig. 3). The AUC_{ROC} of FPG (0.782 (0.726, 0.839)) and HbA1c (0.801 (0.743, 0.859)) were significantly smaller to 2 h-PG (ΔAUC for FPG = –0.124 (–0.184, –0.065), $P < 0.001$; and ΔAUC for HbA1c = –0.105 (–0.169, –0.041), $P = 0.001$;

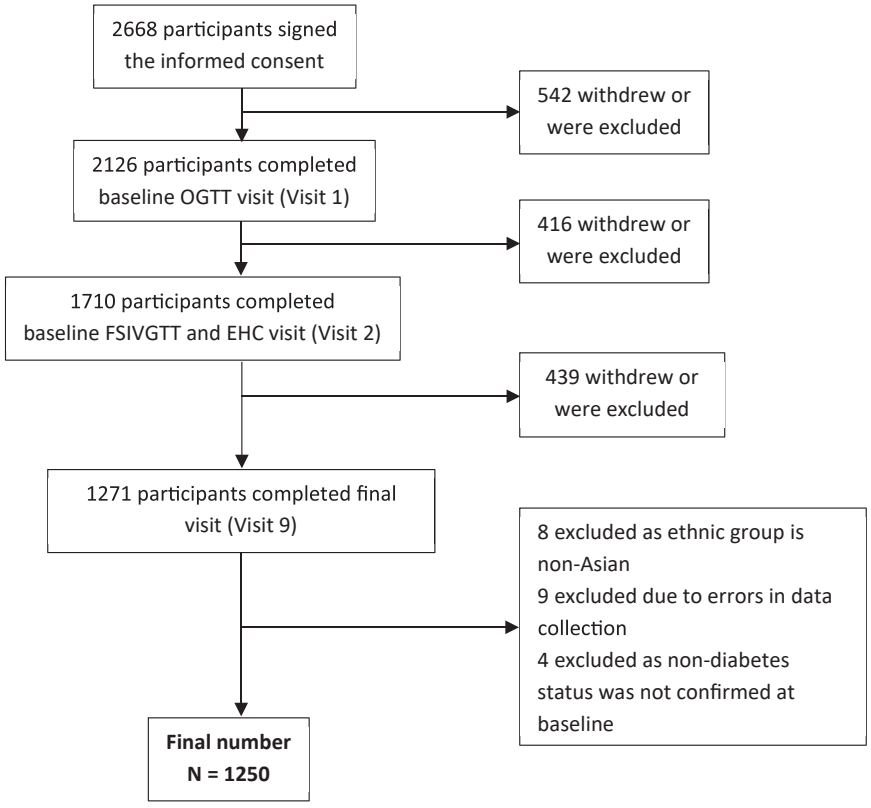

Fig. 1: Participant flowchart.

N	1250
Prediabetes, N (%)	508 (40.6%)
Incident T2D, N (%)	77 (6.2%)
Age, yrs	47.7 ± 9.8
Sex, N (%)	
Males: Females	541 (43%): 709 (57%)
Ethnic group, N (%)	
Chinese	878 (70%)
Malay	140 (11%)
Indian	181 (14%)
Other	51 (4%)
BMI (kg/m^2)	25.0 ± 4.4
Waist-to-hip ratio	0.870 ± 0.061
2 h-PG (mmol/L)	6.3 ± 1.9
1 h-PG (mmol/L)	8.8 ± 2.4
Fasting PG (mmol/L)	4.9 ± 0.5
HbA1c (%)[a]	5.5 ± 0.4

Data is displayed as mean ± SD or N (%). [a]N = 1242.

Table 1: **Baseline characteristics of the study population.**

respectively, Table 2), indicating an inferior discriminatory ability for T2D. When the ROC curve analyses were adjusted for age, sex, ethnic group, and either BMI or body weight, the conclusions remained the same (Supplementary Table S1). Similarly, the NRI and IDI analyses comparing the discriminatory ability of 1 h-PG against 2 h-PG showed slight differences of marginal significance, overall indicating that the net proportion of correctly predicted T2DM was slightly improved when using 1 h-PG over 2 h-PG (Supplementary Table S2).

Given the performance of 1 h-PG was on par with 2 h-PG, using 1 h-PG in clinical settings would be less time-consuming for the clinician and less burdensome for the patient. We subsequently attempted to identify the optimal 1 h-PG threshold for T2DM prediction performance as a potential clinical screening tool. The 1 h-PG threshold that maximized the sum of sensitivity (0.831) and specificity (0.812) in predicting T2DM in our Asian population was ≥10.7 mmol/L (Supplementary Table S3). At this cut-off, the prevalence of participants who had elevated 1 h-PG was 23%, with positive predictive value = 0.225 and negative predictive value = 0.987 (Supplementary Table S3). This meant that of the 1250 participants, 284 had a 1 h-PG value equal to or higher than 10.7 mmol/L at baseline, and 22.5% of them would develop T2DM within three years vs. 1.3% of participants with 1 h-PG <10.7 mmol/L at baseline. During the study, out of the 77 participants who developed T2DM (ranging from six months to three years after baseline), 91% of them had 1 h-PG ≥ 10.7 mmol/L during the OGTT at the time of conversion, which is comparable to 99% of them having 2 h-PG ≥ 7.8 mmol/L.

Elevated 1 h-PG is associated with impaired AIR and β-cell function

To investigate whether 1 h-PG ≥ 10.7 mmol/L identifies a metabolically abnormal subgroup of the population independent of IGT (i.e., 2 h-PG ≥ 7.8 mmol/L), we looked at the baseline data of a subset of participants who had both FPG <5.6 mmol/L and HbA1c < 5.7% and

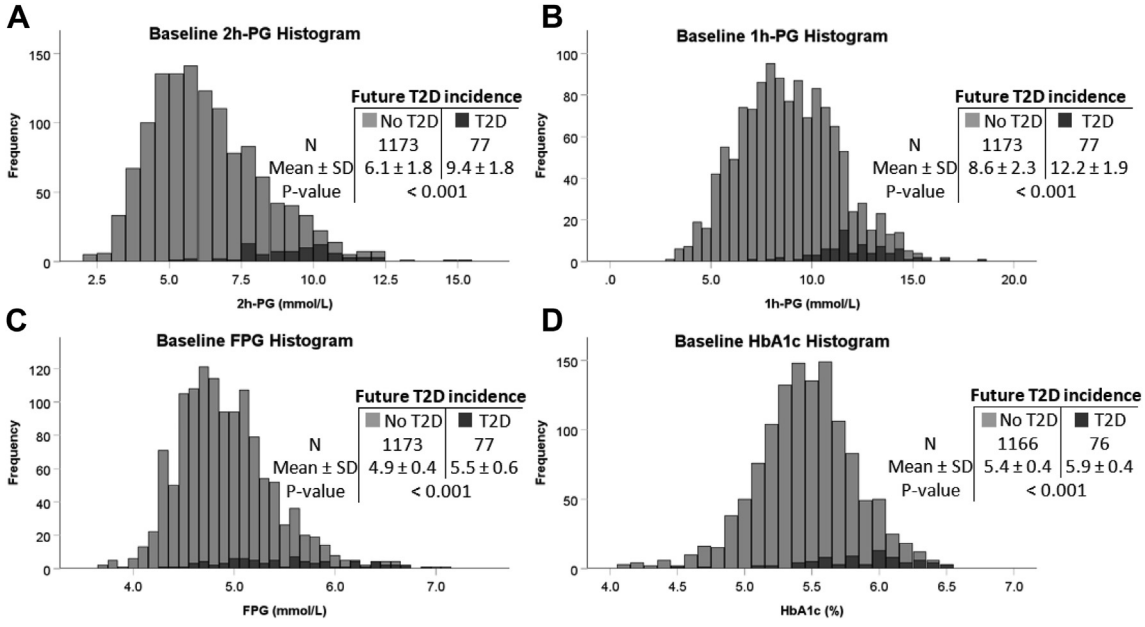

Fig. 2: Population distribution of glucose parameters at baseline of future T2DM converters vs. non-converters: (A) 2 h plasma glucose after OGTT, (B) 1h plasma glucose after OGTT, (C) fasting plasma glucose, (D) HbA1c. Student's T-test for independent samples was used.

categorized them into normal glucose tolerance (NGT: 1 h-PG < 10.7 mmol/L and 2 h-PG < 7.8 mmol/L), 1 h-PG_{high} only (1 h-PG ≥ 10.7 mmol/L and 2 h-PG < 7.8 mmol/L), 2 h-PG_{high} only (1 h-PG < 10.7 mmol/L and 2 h-PG ≥ 7.8 mmol/L), or both 1 h-PG_{high} and 2 h-PG_{high} (1 h-PG ≥ 10.7 mmol/L and 2 h-PG ≥ 7.8 mmol/L). Of the 857 participants, 684 were NGT, 51 had 1 h-PG_{high} only, 54 had 2 h-PG_{high} only and 68 had both 1 h-PG_{high} and 2 h-PG_{high} (Table 3). The four groups were significantly different in sex and BMI, and these parameters together with age and ethnic group were adjusted for in Table 3. As expected, compared to the NGT group, the combined 1 h-PG_{high} and 2 h-PG_{high} group had the highest glucose levels (fasting glucose, 1 h-PG, 2 h-PG and HbA1c), followed by the 1 h-PG_{high} only and the 2 h-PG_{high} only groups. Aside from the combined 1 h-PG_{high} and 2 h-PG_{high} group having slightly elevated triglyceride and ALT concentrations and slightly lower HDL concentrations vs. NGT, there were no differences in body fat distribution, lipid panel, blood pressure and pulse rate between groups. Fasting insulin was slightly elevated in the two groups with high 1 h-PG, but only 1 h-PG_{high} group had significantly higher levels than the NGT group. While peripheral insulin sensitivity (M/I) was significantly lower than NGT only in the combined 1 h-PG_{high} and 2 h-PG_{high} group, AIR and DI were significantly lower in the two groups with elevated 1 h-PG vs. the NGT group, indicating an impairment in the β-cell response was associated with elevated 1 h-PG (Table 3).

From the correlation analysis, both 1 h-PG and 2 h-PG correlated significantly with M/I ($R_{1h\text{-}PG}$ = –0.247, P < 0.001; $R_{2h\text{-}PG}$ = –0.295, P < 0.001), while the absolute magnitude was larger for 2 h-PG, there was no significant difference in the strength of association of 1 h-PG and 2 h-PG with M/I (Steiger's Z test P = 0.062). In contrast, only 1 h-PG was significantly correlated with AIR ($R_{1h\text{-}PG}$ = –0.118, P < 0.001; $R_{2h\text{-}PG}$ = –0.005, P = 0.874). In terms of overall β-cell function reflected by the DI, there was a stronger association with 1 h-PG than with 2 h-PG ($R_{1h\text{-}PG}$ = –0.332, P < 0.001; $R_{2h\text{-}PG}$ = –0.207, P < 0.001; Steiger's Z test P < 0.001). When the full participant population of 1250 was analyzed, the correlation trends were similar although significance was also observed between 2 h-PG and AIR, and 2 h-PG had a stronger association with M/I than 1 h-PG (Supplementary Table S4).

Discussion

Consistent with previous studies in non-Asian populations,[9,10] we have found that 1 h-PG is an adequately good predictor of future T2DM incidence in Asians with almost all those who converted to T2DM (91%) exhibiting elevated 1 h-PG levels at the time of conversion. However, the optimal threshold for risk detection in our population was 10.7 mmol/L, much higher than the recommended value of 8.6 mmol/L in non-Asian populations. The diagnostic performance of 1 h-PG based on that cutoff was on par with 2 h-PG. When we used other measures of T2DM risk—such as presence of prediabetes or IGT—as the discriminatory outcomes in the ROC curve analysis, the threshold values were 9.4 mmol/L and 9.6 mmol/L, respectively, still considerably higher than 8.6 mmol/L (Supplementary Table S5), suggesting a differential response in Asians compared with those in the San Antonio Heart Study, and the Botnia and Malmö Prevention Study cohorts, which comprised predominantly Caucasian populations.[9,10] This is likely related to the Asian metabolic phenotype being substantially different from the Caucasian one.[33] One such difference could be in the rate of gastric emptying, which in turn directly affects the early post-prandial glucose response.[34] A small study by Wang et al. found that Chinese individuals had more rapid gastric emptying than Caucasians and this was associated with greater post-prandial glycemic excursions.[35] Other East Asian studies have reported higher threshold values of 1 h-PG as an indicator for T2DM risk. Besides the cohort studies highlighted earlier,[18,19] a Chinese study of 2886 participants reported an optimal 1 h-PG diagnostic threshold for prediabetes of 10.1 mmol/L,[36] and a Japanese study of 918 participants reported an 1 h-PG ≥ 9.4 mmol/L as the optimal threshold for presence of IGT.[37] These results

Parameter	ROC (95% CI)	*P*-value	ΔAUC vs. 2 h-PG	*P*-value vs. 2 h-PG
2 h-PG	0.907 (0.878, 0.935)	<0.0001	–	–
1 h-PG	0.883 (0.849, 0.917)	<0.0001	−0.024 (−0.054, 0.007)	0.12
FPG	0.782 (0.726, 0.839)	<0.0001	−0.124 (−0.184, −0.065)	<0.0001
HbA1c[a]	0.801 (0.743, 0.859)	<0.0001	−0.105 (−0.169, −0.041)	0.0013

Receiver Operator Characteristics (ROC) curve analysis was used to assess the ability of the glucose parameters in discriminating future T2DM converters from controls at baseline in 1250 non-diabetic Asian participants.
[a]N = 1242.

Table 2: **ROC curve analysis of glucose parameters for T2DM incidence.**

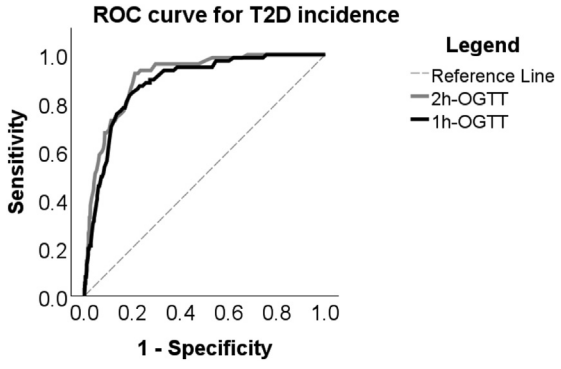

Fig. 3: ROC curves of baseline 1 h-PG vs. 2 h-PG for T2DM incidence.

Parameter	NGT	1 h-PG$_{high}$ only	2 h-PG$_{high}$ only	1 h-PG$_{high}$ & 2 h-PG$_{high}$	*P*-value
N (%)	684 (80%)	51 (6%)	54 (6%)	68 (8%)	–
Sex, N (%)					
Males	283 (41%)	31 (61%)	17 (31%)	33 (49%)	0.012
Females	401 (59%)	20 (39%)	37 (69%)	35 (51%)	
Ethnic group, N (%)					
Chinese	491 (72%)	35 (69%)	32 (59%)	49 (72%)	0.19
Malay	66 (10%)	4 (8%)	12 (22%)	8 (12%)	
Indian	101 (15%)	8 (16%)	7 (13%)	6 (9%)	
Other	26 (4%)	4 (8%)	3 (6%)	5 (7%)	
Age (yrs)	45.7 (45.0, 46.3)	46.1 (43.0, 49.1)	42.3 (40.1, 44.4)	45.5 (43.1, 47.8)	0.077
BMI (kg/m^2)	24.3 (24.0, 24.6)	24.9 (23.4–26.4)	26.8 (25.3–28.2)[b]	25.7 (24.8–26.7)[c]	<0.0001
Waist-to-hip ratio	0.870 (0.864, 0.877)	0.873 (0.858, 0.888)	0.886 (0.871, 0.890)	0.886 (0.873, 0.899)	0.031
Body fat (%)	28.3 (28.0, 28.6)	28.5 (27.4, 29.6)	28.8 (27.7, 29.8)	28.0 (27.1, 29.0)	0.89
Fasting PG (mmol/L)	4.7 (4.7, 4.8)	4.8 (4.7, 4.9)	4.8 (4.7, 4.9)	4.9 (4.8, 5.0)[c]	0.0011
1 h-PG (mmol/L)	7.4 (7.2, 7.5)	11.3 (10.8, 11.7)[a]	9.3 (8.9, 9.8)[b,d]	11.6 (11.2, 11.9)[c,f]	<0.0001
2 h-PG (mmol/L)	5.2 (5.1, 5.3)	6.2 (5.9, 6.5)[a]	8.4 (8.0, 8.7)[b,d]	9.1 (8.8, 9.4)[c,e,f]	<0.0001
HbA1c (%)	5.2 (5.2, 5.3)	5.3 (5.2, 5.4)	5.3 (5.2, 5.4)	5.3 (5.3, 5.4)[c]	0.0011
Triglycerides (mmol/L)	1.1 (1.0, 1.2)	1.2 (1.1, 1.4)	1.3 (1.2, 1.5)	1.4 (1.3, 1.6)[c]	<0.0001
Total cholesterol (mmol/L)	5.1 (5.0, 5.2)	5.1 (4.9, 5.3)	5.2 (4.9, 5.4)	5.2 (5.0, 5.4)	0.59
HDL cholesterol (mmol/L)	1.4 (1.3, 1.4)	1.4 (1.3, 1.4)	1.3 (1.2, 1.4)	1.3 (1.2, 1.4)[c]	0.023
LDL cholesterol (mmol/L)	3.4 (3.3, 3.5)	3.4 (3.2, 3.6)	3.5 (3.3, 3.7)	3.6 (3.4, 3.7)	0.21
Systolic BP (mmHg)	122 (121, 124)	123 (119, 127)	125 (122, 129)	125 (122, 128)	0.20
Diastolic BP (mmHg)	76 (75, 77)	76 (74, 79)	79 (76, 81)	77 (75, 80)	0.12
Pulse (bpm)	71 (69, 72)	72 (69, 75)	72 (69, 74)	72 (70, 75)	0.42
ALT (U/L)[g]	22 (20, 23)	22 (18, 26)	22 (18, 26)	27 (24, 31)[c]	0.018
eGFR (ml/min)	103 (102, 103)	104 (100, 106)	105 (103, 108)	104 (102, 106)	0.082
Fasting insulin (mU/L)	8.6 (8.1, 9.1)	10.7 (9.3, 12.0)[a]	9.5 (8.2, 10.8)	10.1 (8.9, 11.2)	0.0019
M/I (mg·ml/(mU·kg·min))	94.5 (90.5, 98.6)	90.2 (80.4, 100.1)	82.2 (72.3, 92.0)	69.0 (60.2, 77.8)[c,e]	<0.0001
AIR (mU·min/L)	788 (722, 853)	513 (354, 672)[a]	684 (525, 842)	550 (408, 691)[c]	<0.0001
DI (M/I x AIR x 10^{-3})	64.1 (59.9, 68.2)	42.4 (32.4, 52.5)[a]	47.6 (37.6, 57.6)[b]	33.0 (24.1, 42.0)[c]	<0.0001

Continuous variables are displayed as mean (95% CI). Pearson's Chi-square test was used for sex and Likelihood ratio Chi-square test was used for ethnic group. For age and BMI, ANOVA was performed with Sidak post-hoc test for pairwise comparisons. For the rest of the continuous variables, general linear model was performed adjusted for sex, ethnic group, age and BMI, with Sidak post-hoc test for pairwise comparisons. [a]NGT vs. 1 h-PG$_{high}$ only. [b]NGT vs. 2 h-PG$_{high}$ only. [c]NGT vs. 1 h-PG$_{high}$ and 2 h-PG$_{high}$. [d]1 h-PG$_{high}$ only vs. 2 h-PG$_{high}$ only. [e]1 h-PG$_{high}$ only vs. 1 h-PG$_{high}$ and 2 h-PG$_{high}$. [f]2 h-PG$_{high}$ only vs. 1 h-PG$_{high}$ and 2 h-PG$_{high}$. [g]N = 52 for 2 h-PG$_{high}$ only group.

Table 3: **Comparison of metabolic parameters between groups of non-diabetic Asians with and without isolated or combined elevated 1 h-PG and 2 h-PG.**

corroborate our findings in a predominantly Chinese (70%) population (Table 1). Moreover, repeating the analyses using only the Chinese participants (N = 878) yielded an optimal 1 h-PG cut-off of 10.4 mmol/L, which would be even closer to what has been reported so far in other studies. It is noted that two cohort studies (the Korean study[17] and a small Chinese study (n = 116)[38]) are discordant with lower proposed 1 h-PG cut-offs of 8.0–8.55 mmol/L. Subtle differences in thresholds may be due to the analytic method of glucose measurement used in different studies – the hexokinase method was reported to have a positive systematic bias of 0.2 mmol/L vs. the glucose oxidase method.[39] Some variability in thresholds can also be attributed to the different follow up durations.[40] For example, over our 3-year study, 1 h-PG performed similarly to 2 h-PG in predicting T2DM, but studies with longer follow-up reported 1 h-PG was superior to 2 h-PG.[41]

This study underscores the importance of not assuming a one-size-fits-all approach as different ethnic populations are unique in their etiology of T2DM progression. Compromising specificity for a higher sensitivity is a good strategy for screening, as it will increase chances of detecting those at risk of T2DM, while the false positives will still benefit from a diabetes prevention program that improves their lifestyle and diet choices. However, due to the much higher prevalence of 1 h-PG ≥ 8.6 mmol/L at 53.0% compared with 1 h-PG ≥ 10.7 mmol/L at 22.7%, the percentage of false positives (FP/Total = (1–PPV) x prevalence) captured would rise significantly from 17.6% to 47.2% if 8.6 mmol/L was used instead of 10.7 mmol/L. Because the NPV values do not differ much, the resulting decrease in percentage of false negatives (FN/total = (1–NPV) x (1–prevalence)) would be less severe, from 1.0% to 0.3%. Hence, using the global recommendation of 8.6 mmol/L would place

an unnecessary economic burden on population screening for T2DM risk from a population health perspective.

All else being equal, choosing 1 h-PG over 2 h-PG would be preferred since it is logistically easier, faster, and more cost-effective for service providers, and more convenient for patients. In a simulation model to estimate the long-term cost-effectiveness of using 1 h-PG vs. 2 h-PG for screening and assessing T2DM risk over 35 years, the 1 h-PG projected an overall cost saving of approximately 8900 USD per quality-adjusted life year gained.[42] Besides being a good predictor of T2D, 1 h-PG also performs similarly to, or better than, 2 h-PG in predicting incidence of diabetes complications such as retinopathy,[43] cardiovascular disease[44,45] and all-cause mortality.[25,44] Given these findings, a formal petition was made to replace current 2 h-PG IGT criteria for diagnosing prediabetes with 1 h-PG $\geq$ 8.6 mmol/L in 2018,[46] and the International Diabetes Federation recently published a position statement supporting the use of 1 h-PG[14]

While the 2 h-PG had a slightly stronger association with insulin action (M/I), the 1 h-PG was more closely associated with insulin secretion (AIR), a conclusion similar to that reached by Paddock et al.[40] Our data indicated that overall β-cell function (reflected by the DI = AIR x M/I), was more closely associated with 1 h-PG suggesting that 1 h-PG is a better indicator of β-cell dysfunction than 2 h-PG. While findings from other studies vary in regards to the association of these two glucose indices with insulin sensitivity (M/I), their conclusions on AIR and β-cell function are similar to our study,[12,47] reinforcing our conclusion that 1 h-PG is closely linked with β-cell function. This does not diminish the importance of insulin resistance nor IGT in T2DM progression, In fact, in our study, the percentage conversion to T2DM within three years was highest in individuals with combined elevated 1-h PG and IGT (30.7%), than with isolated 1 h-PG alone (8.6%), highlighting the importance of both insulin sensitivity and secretion defects in the pathogenesis to T2DM. Also, about two-thirds of individuals with elevated 1 h-PG had IGT, indicating that the underlying pathophysiology of these two phenotypes is highly intertwined (Supplementary Table S6). However, given the central role of β-cell dysfunction in the pathogenesis of T2DM,[48] and the higher contribution of impaired insulin secretion towards the development of T2DM in East Asians,[49,50] using the 1 h-PG to identify those at risk of T2DM would be highly clinically relevant in this population.

The main strengths of our study are its large size and the deep metabolic phenotyping of participants which is unique among Asians. Through gold standard physiology measures of insulin sensitivity (M/I derived from the hyperinsulinemic-euglycemic clamp) and insulin secretion (AIR) in this large cohort, we are able to characterize the associations of impaired insulin secretion, insulin resistance and β-cell dysfunction with elevated 1 h-PG, building on the knowledge of previous studies in predominantly Caucasian populations. However, a major limitation is that the short follow-up period of three years does not adequately capture long-term T2DM risk, which may be more relevant from a population health standpoint. As this study was based in Singapore, it might not accurately reflect the Asian population in the region due to country-specific differences in healthcare access and other socio-economic factors which can affect glycemic responses and diabetes onset.

In conclusion, the diagnostic performance of 1 h-PG to detect Asians at risk of developing T2DM within three years is on par with 2 h-PG. The optimal threshold for identifying those at high risk is 10.7 mmol/L, which is significantly higher than the widely used cut-off of 8.6 mmol/L. A lengthier duration of follow-up would be needed to validate the utility of 10.7 mmol/L in the assessment of T2DM risk beyond three years. Elevated 1 h-PG was associated with impaired insulin secretion and β-cell dysfunction. Given the relatively higher contribution of impaired insulin secretion in the pathogenesis of T2DM in East Asians which represents the majority in our study population, as well as the time- and cost-saving advantage over the 2 h-PG, we recommend the 1 h-PG be considered as the primary post-load glucose time point to identify Asians in this region who are at elevated risk for T2DM.

Contributors

Michelle H. Lee, Maybritte Lim, Faidon Magkos and Sue-Anne Toh were involved in the study design, Michelle H. Lee, Maybritte Lim, Eveline Febriana and Sue-Anne Toh were involved in the conduct of the study and data collection. Michelle H. Lee and Eveline Febriana analyzed the data and drafted the manuscript. All authors were responsible for the data interpretation, critical review and intellectual input, and approving the final version of the manuscript. Michelle H. Lee is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Data sharing statement

The data are not publicly available due to ethical restrictions but can be made available upon reasonable request with the submission of an appropriate research plan, and pending approval by the corresponding and senior authors.

Editor note

The Lancet Group takes a neutral position with respect to territorial claims in published maps and institutional affiliations.

Declaration of interests

Sue-Anne Toh is a board member and shareholder in NOVI Health (Singapore); has served on the advisory board for Novo Nordisk, Eli Lilly, Janssen, Boehringer-Ingelheim, Merck, Abbott and Astra Zeneca; is a member of the speaker's bureau for Eli Lilly, Boehringer-Ingelheim, DKSH, Merck, Abbott and Astra Zeneca; has received research support from Janssen, Merck and National Medical Research Council (NMRC), Singapore. Faidon Magkos has received funding for other studies from the Novo Nordisk Foundation. M.H.L is an employee in NOVI Health (Singapore). Alice Pik-Shan Kong has received research

grants and/or speaker honoraria from Abbott, Astra Zeneca, Bayer, Boehringer Ingelheim, Dexcom, Eli-Lilly, Kyowa Kirin, Merck Serono, Merck Sharp & Dohme, Nestle, Novo-Nordisk, Pfizer, Sanofi and Zuellig Pharma. The remaining authors have no conflicts of interest to declare that are relevant to the content of this article.

Acknowledgements

The authors express their heartfelt thanks to the following: study participants for their participation, the APT-2D study team for participant recruitment and conducting the clinical procedures, the Investigational Medicine Unit and Outpatient Parenteral Antibiotic Therapy unit of NUH for the usage of the clinical facilities, Saw Swee Hock School of Public Health of NUS, and the National University Health System Regional Health System for their assistance in participant recruitment.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2024.101278.

References

1 Kodama S, Horikawa C, Fujihara K, et al. Use of high-normal levels of haemoglobin A(1C) and fasting plasma glucose for diabetes screening and for prediction: a meta-analysis. *Diabetes Metab Res Rev*. 2013;29(8):680–692.
2 Jagannathan R, Neves JS, Dorcely B, et al. The oral glucose tolerance test: 100 Years later. *Diabetes Metab Syndr Obes*. 2020;13:3787–3805.
3 Parappil A, Doi SA, Al-Shoumer KA. Diagnostic criteria for diabetes revisited: making use of combined criteria. *BMC Endocr Disord*. 2002;2(1):1.
4 Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. National Diabetes Data Group. *Diabetes*. 1979;28(12):1039–1057.
5 Bergman M, Jagannathan R, Buysschaert M, et al. Lessons learned from the 1-hour post-load glucose level during OGTT: current screening recommendations for dysglycaemia should be revised. *Diabetes Metab Res Rev*. 2018;34(5):e2992.
6 Sorensen BM, Houben AJ, Berendschot TT, et al. Prediabetes and type 2 diabetes are associated with generalized microvascular dysfunction: the maastricht study. *Circulation*. 2016;134(18):1339–1352.
7 Su Y, Liu XM, Sun YM, Wang YY, Luan Y, Wu Y. Endothelial dysfunction in impaired fasting glycemia, impaired glucose tolerance, and type 2 diabetes mellitus. *Am J Cardiol*. 2008;102(4):497–498.
8 Bjarnason TA, Hafthorsson SO, Kristinsdottir LB, et al. Oral glucose tolerance test predicts increased carotid plaque burden in patients with acute coronary syndrome. *PLoS One*. 2017;12(8):e0183839.
9 Alyass A, Almgren P, Akerlund M, et al. Modelling of OGTT curve identifies 1 h plasma glucose level as a strong predictor of incident type 2 diabetes: results from two prospective cohorts. *Diabetologia*. 2015;58(1):87–97.
10 Abdul-Ghani MA, Williams K, DeFronzo RA, Stern M. What is the best predictor of future type 2 diabetes? *Diabetes Care*. 2007;30(6):1544–1548.
11 Peddinti G, Bergman M, Tuomi T, Groop L. 1-Hour post-OGTT glucose improves the early prediction of type 2 diabetes by clinical and metabolic markers. *J Clin Endocrinol Metab*. 2019;104(4):1131–1140.
12 Manco M, Panunzi S, Macfarlane DP, et al. One-hour plasma glucose identifies insulin resistance and beta-cell dysfunction in individuals with normal glucose tolerance: cross-sectional data from the Relationship between Insulin Sensitivity and Cardiovascular Risk (RISC) study. *Diabetes Care*. 2010;33(9):2090–2097.
13 Ha J, Chung ST, Bogardus C, Jagannathan R, Bergman M, Sherman AS. One-hour glucose is an earlier marker of dysglycemia than two-hour glucose. *Diabetes Res Clin Pract*. 2023;203:110839.
14 Bergman M, Manco M, Satman I, et al. International Diabetes Federation Position Statement on the 1-hour post-load plasma glucose for the diagnosis of intermediate hyperglycaemia and type 2 diabetes. *Diabetes Res Clin Pract*. 2024;209:111589.
15 Sai Prasanna N, Amutha A, Pramodkumar TA, et al. The 1h post glucose value best predicts future dysglycemia among normal glucose tolerance subjects. *J Diabetes Complications*. 2017;31(11):1592–1596.
16 Priya M, Anjana RM, Chiwanga FS, Gokulakrishnan K, Deepa M, Mohan V. 1-hour venous plasma glucose and incident prediabetes and diabetes in Asian indians. *Diabetes Technol Ther*. 2013;15(6):497–502.
17 Oh TJ, Lim S, Kim KM, et al. One-hour postload plasma glucose concentration in people with normal glucose homeostasis predicts future diabetes mellitus: a 12-year community-based cohort study. *Clin Endocrinol*. 2017;86(4):513–519.
18 Oka R, Aizawa T, Miyamoto S, Yoneda T, Yamagishi M. One-hour plasma glucose as a predictor of the development of Type 2 diabetes in Japanese adults. *Diabet Med*. 2016;33(10):1399–1405.
19 Rong L, Luo N, Gong Y, Tian H, Sun B, Li C. One-hour plasma glucose concentration can identify elderly Chinese male subjects at high risk for future type 2 diabetes mellitus: a 20-year retrospective and prospective study. *Diabetes Res Clin Pract*. 2021;173:108683.
20 Kumpatla S, Parveen R, Stanson S, Viswanathan V. Elevated one hour with normal fasting and 2 h plasma glucose helps to identify those at risk for development of Type 2 Diabetes-11 years observational study from south India. *Diabetes Metab Syndr*. 2019;13(4):2733–2737.
21 Thewjitcharoen Y, Elizabeth Jones A, Butadej S, et al. Elevated 1-h post-load plasma glucose levels in Thai people with normal glucose tolerance associated with high diabetes and cardiovascular risk. *Diabet Med*. 2020;37(4):705–706.
22 Bianchi C, Miccoli R, Trombetta M, et al. Elevated 1-hour postload plasma glucose levels identify subjects with normal glucose tolerance but impaired beta-cell function, insulin resistance, and worse cardiovascular risk profile: the GENFIEV study. *J Clin Endocrinol Metab*. 2013;98(5):2100–2105.
23 Sesti G, Fiorentino TV, Succurro E, et al. Elevated 1-h post-load plasma glucose levels in subjects with normal glucose tolerance are associated with unfavorable inflammatory profile. *Acta Diabetol*. 2014;51(6):927–932.
24 Sciacqua A, Miceli S, Carullo G, et al. One-hour postload plasma glucose levels and left ventricular mass in hypertensive patients. *Diabetes Care*. 2011;34(6):1406–1411.
25 Pareek M, Bhatt DL, Nielsen ML, et al. Enhanced predictive capability of a 1-hour oral glucose tolerance test: a prospective population-based cohort study. *Diabetes Care*. 2018;41(1):171–177.
26 Magkos F, Lee MH, Lim M, et al. Dynamic assessment of insulin secretion and insulin resistance in Asians with prediabetes. *Metabolism*. 2022;128:154957.
27 Xu L, Cheng X, Wang J, et al. Comparisons of body-composition prediction accuracy: a study of 2 bioelectric impedance consumer devices in healthy Chinese persons using DXA and MRI as criteria methods. *J Clin Densitom*. 2011;14(4):458–464.
28 American Diabetes A. 2. Classification and diagnosis of diabetes: standards of medical care in diabetes-2018. *Diabetes Care*. 2018;41(Suppl 1):S13–S27.
29 Pollare T, Vessby B, Lithell H. Lipoprotein lipase activity in skeletal muscle is related to insulin sensitivity. *Arterioscler Thromb*. 1991;11(5):1192–1203.
30 DeFronzo RA, Tobin JD, Andres R. Glucose clamp technique: a method for quantifying insulin secretion and resistance. *Am J Physiol*. 1979;237(3):E214–E223.
31 Brunzell JD, Robertson RP, Lerner RL, et al. Relationships between fasting plasma glucose levels and insulin secretion during intravenous glucose tolerance tests. *J Clin Endocrinol Metab*. 1976;42(2):222–229.
32 Lee IA, Preacher KJ. *Calculation for the test of the difference between two dependent correlations with one variable in common [Computer software]*; 2013. Available from: http://quantpsy.org.
33 Chan JC, Malik V, Jia W, et al. Diabetes in Asia: epidemiology, risk factors, and pathophysiology. *JAMA*. 2009;301(20):2129–2140.
34 Jalleh RJ, Jones KL, Rayner CK, Marathe CS, Wu T, Horowitz M. Normal and disordered gastric emptying in diabetes: recent insights into (patho)physiology, management and impact on glycaemic control. *Diabetologia*. 2022;65(12):1981–1993.
35 Wang X, Xie C, Marathe CS, et al. Disparities in gastric emptying and postprandial glycaemia between Han Chinese and Caucasians with type 2 diabetes. *Diabetes Res Clin Pract*. 2020;159:107951.
36 Zhou W, Gu Y, Li H, Luo M. Assessing 1-h plasma glucose and shape of the glucose curve during oral glucose tolerance test. *Eur J Endocrinol*. 2006;155(1):191–197.
37 Iwao T, Sakai K, Ando E. Meaning of upper limit of normal range of post-load 1-h plasma glucose level defined by oral glucose

tolerance test in Japanese subjects. *J Diabetes Investig*. 2013;4(4):372–375.
38 Kuang L, Huang Z, Hong Z, Chen A, Li Y. Predictability of 1-h postload plasma glucose concentration: a 10-year retrospective cohort study. *J Diabetes Investig*. 2015;6(6):647–654.
39 Dickson LM, Buchmann EJ, Janse Van Rensburg C, Norris SA. The impact of differences in plasma glucose between glucose oxidase and hexokinase methods on estimated gestational diabetes mellitus prevalence. *Sci Rep*. 2019;9(1):7238.
40 Paddock E, Hohenadel MG, Piaggi P, et al. One-hour and two-hour postload plasma glucose concentrations are comparable predictors of type 2 diabetes mellitus in Southwestern Native Americans. *Diabetologia*. 2017;60(9):1704–1711.
41 Nielsen ML, Pareek M, Leosdottir M, et al. Follow-up duration influences the relative importance of OGTT and optimal timing of glucose measurements for predicting future type 2 diabetes. *Eur J Endocrinol*. 2016;174(5):591–600.
42 Andellini M, Manco M, Esposito MT, Tozzi AE, Bergman M, Ritrovato M. A simulation model estimates lifetime health and economic outcomes of screening prediabetes using the 1-h plasma glucose. *Acta Diabetol*. 2023;60(1):9–17.
43 Paddock E, Looker HC, Piaggi P, Knowler WC, Krakoff J, Chang DC. One-hour plasma glucose compared with two-hour plasma glucose in relation to diabetic retinopathy in American Indians. *Diabetes Care*. 2018;41(6):1212–1217.
44 Nielsen ML, Pareek M, Leosdottir M, Eriksson KF, Nilsson PM, Olsen MH. One-hour glucose value as a long-term predictor of cardiovascular morbidity and mortality: the Malmo Preventive Project. *Eur J Endocrinol*. 2018;178(3):225–236.
45 Saunajoki A, Auvinen J, Bloigu A, Ukkola O, Keinanen-Kiukaanniemi S, Timonen M. One-hour post-load glucose improves the prediction of cardiovascular events in the OPERA study. *Ann Med*. 2021;53(1):478–484.
46 Bergman M, Manco M, Sesti G, et al. Petition to replace current OGTT criteria for diagnosing prediabetes with the 1-hour post-load plasma glucose >/= 155 mg/dl (8.6 mmol/L). *Diabetes Res Clin Pract*. 2018;146:18–33.
47 Marini MA, Succurro E, Frontoni S, et al. Insulin sensitivity, beta-cell function, and incretin effect in individuals with elevated 1-hour postload plasma glucose levels. *Diabetes Care*. 2012;35(4):868–872.
48 Saisho Y. beta-cell dysfunction: its critical role in prevention and management of type 2 diabetes. *World J Diabetes*. 2015;6(1):109–124.
49 Morimoto A, Tatsumi Y, Deura K, et al. Impact of impaired insulin secretion and insulin resistance on the incidence of type 2 diabetes mellitus in a Japanese population: the Saku study. *Diabetologia*. 2013;56(8):1671–1679.
50 Ohn JH, Kwak SH, Cho YM, et al. 10-year trajectory of beta-cell function and insulin sensitivity in the development of type 2 diabetes: a community-based prospective cohort study. *Lancet Diabetes Endocrinol*. 2016;4(1):27–34.